with the pitch pills. He recommends that the battery be employed for a quarter of an hour daily. From what we have lately heard of the influence of the continuous current on internal disorders, we might expect good results here. But this is a matter I am still investigating.

Of course in the treatment of the vexatious disease under consideration, we must always search for what may be possibly an exciting cause, and seek to remedy it. Otherwise our best endeavours will come to naught, or certainly the difficulties of treating a malady will be immensely heightened, which, in its more advanced forms, will, under any circumstances, tax all our patience and resources to the utmost, and where success, no matter what the skill employed or the perseverance shown, is not always within our reach.

ART. II.—*Fractures of the Odontoid Process.* By STEPHEN SMITH, M.D., Surgeon to Bellevue Hospital, New York.

THE processus dentatus, or odontoid process, is regarded as the body of the atlas attached to the body of the axis. This fact is proved, both in development and in comparative anatomy. In the development of the vertebral column the chorda dorsalis may be traced through the processus dentatus as through the centre of other vertebræ. This proves that the process is the centrum of a vertebra. In the early period of fœtal life, therefore, it has the anatomical appearances, relations, and histological elements of a centrum, or body of a vertebra. Comparative anatomy demonstrates the same fact. In fishes there is no odontoid process; the centrum of the atlas retains its normal relations to the other elements, and the ordinary mode of articulation with the body of the second vertebra.[1] As we ascend the scale, this process appears more and more distinctly developed, and always in such relations to the atlas as to prove that it occupies the position of its centrum. In man it appears in its highest state of development, and represents the central portion of the body of the atlas, attached to the superior surface of the body of the axis.

In the development of the odontoid process, we have to notice that it

"consists originally of an extension upwards of the cartilaginous mass, in which the lower part of the body (of the axis) is formed. At about the sixth month of fœtal life, two osseous nuclei make their appearance in the base of this process; they are placed laterally, and join before birth to form a conical bilobed mass deeply cleft above. The interval between the cleft and the summit of the process is formed by a wedge-shaped piece of cartilage; the base of the process being separated from the body by a cartilaginous interval, which gradually becomes ossified; sometimes by a separate epiphyseal nucleus." (*Gray.*)

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[1] Owen, Comp. Anat. and Phys. of Vertebrates, vol. ii. p. 41.

The apex has a separate nucleus. (*Humphrey.*) Ossification is not completed until about the fourth year.

This method of development gives great strength to the process. It is so incorporated with the body of the axis that its firm and compact structure is traceable throughout a considerable portion of the body of that bone.

The process is markedly constricted at its base by the transverse ligament. This constriction would seem to diminish very much the strength of the bone, for it is precisely at this point that the greatest strain is brought to bear when violence is applied to the head. But experiments prove that the neck is stronger than the body of the axis.

The odontoid process is maintained in position by the transverse ligament posteriorly, and the anterior ring of the atlas anteriorly. Of these supports, the ring of the atlas is the weakest, and when driven by violence against the process is readily fractured.

The transverse ligament, which has also a crucial arrangement to give greater protection to the spinal cord against possible accidents to the process, has great strength. In the adult subject it will sustain a weight of upwards of two hundred pounds, as will be seen, without yielding. When violence is applied it will frequently tear off its attachments to the axis before its fibres yield.

The moderator, check, or odontoid ligaments attach the upper extremity of the process to the margins of the foramen magnum, and serve as checks upon the movements of the head, not only in rotation, but also in flexion and extension.

Experiments prove not only that the odontoid process has enormous strength, but also that the ligaments which maintain it have remarkable tenacity, and that before their fibres yield, they separate their bony attachments.

The subjoined experiments were made with a view to determine the absolute and relative strength of the odontoid process, its ligaments, etc.

The following experiments illustrate the strength of the odontoid process:—

Expt. 1.—The axis, taken from a recent subject, a well-formed adult male, and separated from all connections with other parts, was suspended firmly. An iron four pound weight, dropped upon its projecting extremity from a height of two feet, did not fracture it. When the weight fell from a height of four feet, the process separated, carrying with it the central portion of the body of the axis. In this case, the process had already sustained a direct weight of two hundred and twenty pounds, suspended from its neck.

Expt. 2.—In a specimen which had resisted upwards of one hundred pounds vigorous and repeated blows with a hammer upon the side of the projecting extremity of the process, the final result was fracture of the laminæ of the axis, but the process remained firm and unyielding.

The next experiments were designed to test the comparative strength of the transverse ligament, the anterior ring of the atlas, and the odontoid process, by means of weights suspended so as to place these parts in antagonism :—

Expt. 3.—The two upper cervical vertebræ were removed, and the connections of the atlas and the occiput carefully dissected away. The vertebræ were suspended upon a strong nail passing through the spinal canal so as to sustain the axis, but the atlas was free. A weight was then suspended to the posterior ring of the atlas, amounting, finally, to one hundred and twenty pounds, when the nail broke, but the process remained intact.

Expt. 4.—The axis was now suspended, the atlas being free, except the transverse ligament, and the fastenings firmly attached to both transverse processes of the atlas. A weight suspended from these fastenings was sustained entirely by the transverse ligament and process. Weights to the amount of one hundred and sixty pounds were employed, but failing to break the ligament or process, a man, weighing two hundred and twenty pounds, stepped into a sling attached to the fastenings and remained suspended several minutes before the parts yielded. On examination, it was found that the anterior ring of the atlas had broken, but the process and ligaments were firm, and apparently uninjured.

In order to test the effects of blows which would drive the process forcibly against the anterior ring of the atlas, the experiment was made as follows :—

Expt. 5.—The soft parts of the neck of a well-developed male subject were removed. The body was raised and allowed to fall so as to strike heavily upon the occiput, but no result followed. Direct blows were then given to the anterior face of the ring of the atlas, driving it violently against the process; this resulted in fracturing the ring of the atlas, the process remaining uninjured.

The next experiment was designed to test the comparative strength of the transverse ligament when driven against the process.

Expt. 6.—The soft parts being dissected away, except the ligaments, from the neck of an adult subject, the body was thrown upon the forehead with great violence, but without result. The posterior ring of the atlas was then struck and fractured, but neither the ligament nor process was affected.

On repeating these experiments I made several efforts to fracture the process at its neck by direct violence.

Expt. 7.—In several subjects the axis was fixed, and violent blows given to the anterior and posterior surfaces of the extremity of the process with the invariable result of fracturing the body of the axis in two places, the central portion remaining attached to the base of the process.

Failing in these several experiments to fracture the process by the application of violence in the manner of the various accidents which are supposed to cause the fracture, it occurred to me that the true explanation of these fractures might possibly be the traction of the strong moderator ligaments upon the extremity of the process in the various violent movements of the head in severe injuries, as blows, falls, &c. The next experiments were undertaken to determine the comparative strength of these ligaments.

Expt. 8.—The base of the skull with the atlas, axis, and two adjacent vertebræ, were taken from the body of a woman apparently forty years of age, and all the attachments between the atlas and occiput and atlas and axis were severed except the check ligaments, the transverse ligaments being also preserved. The end of a firm iron rod was passed upwards through the spinal canal to the occiput, but without entering the foramen magnum; the occiput remained firm, and was attached only by the moderator ligaments of the process. A weight of 117 pounds was then suspended from the frontal portion of the base of the skull without any yielding of the parts. This represented a blow upon the occiput.

To test still further the strength of the moderator ligaments compared with the odontoid process, while the preparation was suspended the following additional experiment was made:—

Expt. 9.—While the weight of 117 pounds was still suspended from the frontal portion of the skull, a heavy blow was given to the occiput with a mallet which resulted in a separation of the check ligaments from their attachments to the condyloid processes of the occiput. In this separation the entire bony attachments of the ligaments were removed, the ligaments remaining intact. The odontoid process was uninjured, though the full stress of the blow fell upon its neck, and upon the check ligaments attached to its apex.

Expt. 10.—The same experiment was repeated upon specimens taken from a man between fifty and sixty years of age. A weight of 117 pounds ruptured the moderator ligaments near their attachments to the occiput, at a point where it was found that these ligaments had been wounded in the dissection.

These experiments were repeated on a specimen obtained from a still-born child, well developed.

Expt. 11.—The preparation having been dissected as in the other cases, a weight of 7¾ pounds was employed, which, after being sustained for a moment, drew away the odontoid process at its neck. The separation was through the cartilage of the odontoid process at its junction with the body of the axis.

Expt. 12.—The further experiment was repeated of testing the strength of the check ligaments in their attachment to the extremity of the odontoid process, and the condyloid processes of the occiput. A weight of 5¾ pounds detached one ligament, with its bony insertion, from the condyle of the occiput.

Expt. 13.—In a preparation taken from a woman aged thirty-five years, the weight was attached to the occiput and the stress was laid upon the check ligaments, the odontoid process, and the transverse ligament. A weight of 111 pounds, after a moment's suspension, dragged away the condyloid attachments of the check ligaments, the bone separating over the entire attachments of the ligaments. This experiment illustrated the effects of a blow upon the forehead.

Expt. 14.—In another preparation, the subject being a woman, 88 pounds were suspended from the transverse processes of the atlas, the stress in this case being upon the anterior ring of the atlas and neck of the odontoid process. This resulted in fracture of the ring of the atlas at the insertion of the transverse ligament.

The following conclusions are established by these experiments:—

1. In a healthy condition of the parts, the odontoid process has greater strength than either the anterior ring of the atlas or the transverse ligament.

2. The odontoid process is less liable to be fractured by external violence than the body of the axis at the insertion of the process.

3. The odontoid process is not fractured by being driven against the transverse ligament, or anterior arch of the atlas.

4. The odontoid ligaments have a combined strength greater than the odontoid process.

The position of the odontoid process in the skeleton is remarkable.

The axis crowns the spinal column, and the process forms its summit. The atlas belongs to the occiput in all its functions, and yet the odontoid process as its body is the centre of all the movements of the atlas and of the head. It is the centre of two forces, viz: 1st, those acting from the head upon the spinal column will detach the process at its base when external violence is applied to the head; and 2d, those acting from the spinal column upon the head. A recent writer[1] remarks:—

> "Owing to the skull being articulated at its base, near the middle, on the summit of this portion of the column, imaginary lines drawn from the point of junction to the farthest convexities of the skull along its periphery, will represent levers which will act on the axis of motion in the cervical vertebræ, with power commensurate to their different lengths. If a man falling headlong alights upon the parietal convexity of one side, the portion of skull intervening between that eminence and the occipito-atlantal articulation will be like a lever, which will propagate the force with increased power to the cervical vertebræ."

The base of the odontoid process then becomes the point on which these levers act, while the severest strain is upon the odontoid ligaments. On whatever part of the head the person falls, the flexion stretches more or less severely the odontoid ligaments, and these acting upon the extremity of the process, the violence is really expended upon its base.

The function of the odontoid process is to maintain the equilibrium of the head in its various movements upon the spinal column. It is placed in the exact centre of the base of the cranium, and in the centre of the bodies of the vertebræ. It maintains the position of the head by means of the odontoid ligaments, and is itself maintained in proper relations with the spine by the transverse ligament, the ring of the atlas, and the action of the muscles. It follows that when this process is broken the equilibrium of the head is lost, or must be maintained by other means, such as the hands, the muscles, and a very careful carriage of the body. From this results one of the most striking and diagnostic symptoms of this fracture.

Fractures of the odontoid process have been regarded as comparatively rare, or at least they have not been very frequently recognized. Considering the position of this bone, and its functions, and the enormous strain that it must necessarily frequently be subjected to when the body is precipitated upon the head, these fractures must be more common than has been supposed. Surgeons of large experience have intimated that they had met with cases not unfrequently in children, who have recovered.

Mr. Henry Earle, in his remarks upon Mr. Phillips' case of fracture of the odontoid process,

> "Mentioned some interesting cases of injuries occurring to the cervical vertebræ of children, in some of which he had reason to believe that the odontoid process was fractured or broken off. The little patients were generally scrofulous, and met with the accident in play. It was remarkable, in one instance in

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[1] Mr. Shaw, Holmes' Syst. Surg., 2d ed. vol. ii. p. 358.

particular, how tenaciously the child persisted in holding his head fixed between his hands after the occurrence of the injury, nor did he venture to desist from the practice for some days. The cure was attended with complete anchylosis."[1]

Mauchart has also noticed the fact that dislocation between the first and second cervical vertebræ may occur in children from fracture, or separation of the odontoid process.

It has been supposed that these fractures occur from the sudden impulse of the process against either the anterior ring of the atlas or the transverse ligament. I am satisfied, however, that the efficient agents in this fracture are the odontoid ligaments. The experiments detailed show that the anterior ring of the atlas is comparatively weak, and yields when the process is driven against it with even moderate force. Though the transverse ligament is much stronger, it will nevertheless sever its attachments or yield before the process will break. Again, it is apparent that the process is not driven against these parts, with which it lies in contact, with any such force as to cause a fracture. Neither the ring of the atlas nor transverse ligament is ever found injured, unless there are other extensive injuries.

By far the greatest leverage exerted upon the process is through the medium of the odontoid ligaments. Attached near its apex they pass outwards and upwards to their insertion into the sides of the foramen magnum. In the various movements of the head they maintain its exact position upon the spinal column, and restrain its movement within given limits. If now the head is forcibly driven forwards, or backwards, or laterally, the traction is greatest upon the base of the process, or at its attachments to the axis. If the violence is too great, the process must yield, and a fracture will be the result. This, I am satisfied, is the mechanism of fracture of the odontoid process when the violence is applied externally.

Mr. Shaw remarks (*op. cit.*) :—

> "If a man be precipitated from a height, and light upon his head, the impetus of his weight will be conveyed along his spine, and be concentrated at the junction of the column with the base of the skull. Again, the portion of the skull between the point where the head came to the ground and the joint will act with lever power to increase the effect. A violent shock and strain will thus be directed on the atlas and axis. The effects produced vary somewhat. Perhaps the most common is fracture of the processus dentatus at its root, with laceration of the ligamentous connections between the two bones, and dislocation of the atlas forwards. In other cases, the tooth-like process slips from the grasp of the transverse and restraining ligaments, and, freeing the atlas, allows it to slide forwards with the head. Again, the transverse ligament may be ruptured, so as to liberate the processus dentatus, and lead to dislocation. Finally, there may be transverse fracture of the slender arch of the atlas behind the articular processes. In all these injuries but the last, the atlas will have ceased to be restrained by its connection with the odontoid process from sliding horizontally forward on the axis ; the weight of the head will, therefore,

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[1] Lond. Med. Gaz., Feb. 13, 1836, p. 775.

carry it in that direction, and the cord will be compressed by a to and fro action between the ring of the axis, which is stationary, and that of the atlas, which advances. Its substance will be broken up, and the effect will be instantaneous death, as when an animal is pithed."

Fracture of the odontoid process was long supposed to be a constant result in the execution of criminals by hanging. But there is no satisfactory evidence that fracture occurs under such circumstances. On the contrary, the direction of the force would not be such as to lead to such a fracture. Caspar discards this opinion.

These fractures would seem, however, to have a medico-legal interest. In several criminal trials this injury is stated by Taylor[1] to have been the cause of death, and in a case tried at Glasgow it became a material question how far such a fracture might result from disease.

The following collection of cases illustrate the various circumstances and conditions attending fractures of the odontoid process. They may be variously classified, but the following arrangement presents the most striking features recorded:—

I. SPONTANEOUS FRACTURE.—These fractures occur spontaneously, like similar fractures of other bones, from pre-existing conditions which have impaired the integrity of the process.

The following case, reported by Sir Astley Cooper,[2] occurred in a person under treatment for syphilis:—

CASE 1.—A woman who was in the venereal ward at St. Thomas's Hospital, and who was then under a mercurial course, while sitting in bed, eating her dinner, was observed to fall suddenly forward, and the patients hastening to her found that she was dead. Upon examination of her body, the dentiform process of the second vertebra had been broken off; the head, in falling forwards, had forced the root of the process back upon the spinal marrow, which occasioned her instant dissolution.

The following case is referred to by Dr. Abercrombie in his *Observations on Diseases of the Spinal Marrow.*[3] The person was suffering from disease of the tibia, and, as it proved, had also caries of the odontoid process.

CASE 2.—It [the process] may be affected with caries without producing any urgent symptoms, till it suddenly give way and prove fatal. This occurred in a young man mentioned by Mr. Copeland. He had been using mercury for a disease in the tibia, and had for some time complained of stiffness and pain when he moved his head. In making a sudden turn of his head, he was seized with convulsions and died in a few hours. On dissection, the processus dentatus was found completely detached from the vertebra, having been eroded by caries.

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[1] Medical Jurisprudence, 5th Amer. edit., p. 273.

[2] Treatise on Dislocations and Fractures of the Joints, 7th edit., London, 1831, p. 408.

[3] Ed. Med. and Surg. Journ., vol. xiv. p. 42.

An interesting case of spontaneous fracture from pre-existing caries in a person of a scrofulous habit was reported by Dr. A. G. Faywell.[1] The exciting cause was simply a sudden movement of the head backwards.

CASE 3.—A man, æt. 30, scrofulous habit, on May 12th, 1871, suddenly threw his head backward to avoid a ball; felt something give way; swelling occurred at upper and posterior part of neck; had pain in deglutition; on fifth day his head was bent forward, and there was such numbness of the legs as to prevent walking; on sixth day was completely paralyzed, and suddenly died on raising him in bed.

Autopsy.—Odontoid process was fractured at its base and undergoing caries; body of axis carious; internal and external common ligament was destroyed; spinal cord uninjured.

The atlas and axis may become carious, and the disease proceed to that degree that the odontoid process may be entirely destroyed. The following interesting case of this character was reported by Mr. Addison, Surg.:—[2]

CASE 4.—A young lady, aged twenty, began to complain of slight pains about the neck which were attributed to cold; she began to emaciate; preferred the recumbent position; cervical glands became enlarged; at the end of a year pains in hand and neck more severe; motions of head limited; some pain on pressure of the neck close to the head; recumbent posture now more painful than the erect; if in the latter position, the head was supported on the hand or a pillow; movements of a carriage increased pain of neck; some months later there was tenderness over the atlas upon either side, with increase in size of glands; recumbent position still more painful; only rest night and day was sitting up and supporting the head in the hand; pains now extended to shoulder and head; head constantly rested on the hand or the back of a high chair; patient now, upwards of a year after first attack, felt a severe pain dart suddenly up the back part of the head, and it so increased in violence that she took to her bed; soon after, pricking sensations were felt in the fingers of the right superior extremity, and there was evidently a loss of muscular power in it; pains over left side of head were violent and paroxysmal, and attended with numbness of integuments; pressure upon the transverse process of the atlas on the left side brought on the pains of the left side of the head; breathing regular when awake, but irregular and stertorous when asleep; pain now began to be felt in the right side of the head, and pricking and tingling in left arm and fingers; the right upper extremity had by this time nearly lost all motion; this was followed by loss of motion and sensation in the left arm and hand, and finally complete paraplegia supervened; she experienced a grating in the neck whenever the head was moved; she lay in a totally helpless state for about a fortnight, feces and urine passing involuntarily, when she died; mind unaffected.

Autopsy.—On exposing the cervical vertebræ purulent matter escaped, mixed with gritty portions of bone; the anterior portions of the two superior vertebræ were completely carious, especially on left arch; the right superior oblique process of atlas was carious; ligaments destroyed; processus dentatus and all its ligaments destroyed; theca vertebralis infiltrated with pus, but cord appeared normal.

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[1] Ed. Med. and Surg. Journ., vol. viii. p. 132.

[2] Midland Med. and Surg. Reporter, vol. ii. p. 459.

The effects of long-continued pressure of the transverse ligament on the neck of the process have been mentioned as liable to weaken it and predispose to fracture; but as there is a well-formed articulation intervening, it is not probable that this can be regarded as a cause of spontaneous fracture. Nor are there any satisfactory proofs that old age diminishes very materially, or at least to a dangerous degree, the integrity of this bone. The following case of fracture of the axis in such a manner as to include the base of the process, occurring in a man aged 60 years, is the only case I have met with in which old age might be supposed to be the predisposing cause. It was reported by Dr. Copeland.[1]

CASE 5.—"A muscular man, aged about sixty years, the father of a late medical friend, when turning in bed, his head being forcibly pressed on the pillow, so as to partially raise the trunk, felt something snap in his neck. He was afterwards unable to bend or rotate the head without causing much pain in the neck; * * he travelled outside a coach, during the summer, to Cornwall, and returned to town, and not till sixteen months after the accident he complained of numbness and want of power in the left arm. In a day or two the palsy extended to both the upper extremities, but was incomplete in the right. It soon became more general, and in a short time, difficulty of breathing. rapidly terminating in asphyxia, supervened. The body was examined by Prof. R. Quain and myself, and the second cervical vertebra was found fractured completely across on both sides; the fracture of one side passing close to the base of the odontoid process. Chronic inflammation had extended from the fracture to the theca and membranes of the medulla oblongata; lymph was thrown out upon the arachnoid surfaces; the membranes, particularly the dura mater, were much thickened, and ultimately the cord at this part was pressed upon."

Closely allied to the preceding cases, and especially to the last, is separation of the body of the axis from the process. In such cases, though, the odontoid process remains in its position, the separation of its base from the axis is equivalent to a spontaneous fracture, and doubtless would be attended with similar results, were it not that, in the inflammation attendant upon the process of necrosis, anchylosis, more or less complete, of the atlas and axis, precedes the separation. The following case of this kind was reported by Mr. Syme,[2] as a *Case of Recovery after Extensive Exfoliation of the Vertebra Dentata*, with an engraving which shows that "the entire body of the axis, part of the left superior articulating surface, and half of the left vertebral hole," separated, leaving the odontoid process in position.

CASE 6.—Mr. G., æt. about thirty-five, had difficulty of swallowing for a year, which finally became distressing; with the finger detected a large tumour filling up the lower part of the pharynx, pressing forwards upon epiglottis, and leaving merely a narrow channel on each side; punctured the abscess with a trocar, and withdrew pus; detected bare bone in the cavity; was so much relieved that he returned to his employment, and continued at work for a month, when he began to suffer excruciating pains in the neck, which compelled him to retain one fixed posture. In the course of three months the necrosed bone separated, and finally escaped into the throat, and was removed by the patient. He rapidly recovered.

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[1] Dict. Prac. Med., art. Paralysis.

[2] Ed. Med. and Surg. Journ., vol. xxv. p. 311.

On the trial of Robert Reid, for the murder of his wife, at Glasgow, in 1835, Dr. Robertson,[1] one of the witnesses for the prisoner, stated that—

> "Within this last fortnight, it has occurred in the medical wards of the Royal Infirmary, that a patient walking in the wards, suddenly dropped down dead, which, he is informed, arose from fracture of the processus dentatus, the fracture being spontaneous, and the patient dead before reaching the floor."

Taylor, referring to this trial, says it became a material question, how far such a fracture might result from disease. Acquittal took place, partly because the deceased had laboured under disease of the spine, and the exact state of the parts had not been noticed.

Mr. Syme,[2] in his *Clinical Reports for the Summer Session*, 1835, details a case of death from separation of the odontoid ligaments in the course of caries of the atlas and axis, and in a foot-note alludes to Dr. Robertson's statement, and remarks that the case which he now relates is probably the one referred to by Dr. R., as he knew of no other similar case occurring in the Infirmary.

II. Fractures from Direct Violence.—The odontoid process may be fractured by direct violence. All the examples of this kind which I have met, have been gun or pistol shot injuries. Death may result from the direct injuries to the spinal cord, the fracture being merely incidental, and of no immediate importance, as in the following case, reported by Mr. Shaw:—[3]

Case 7.—In the museum of the Middlesex Hospital there is preserved the axis taken from the body of a gentleman who had been shot in the neck, close to the occiput, while asleep lying on his side. The pistol bullet had entered at the mesial line, between the arches of the atlas and axis, had passed horizontally forward, cut through the spinal cord, and been stopped by the odontoid process, against the back of which it was found sticking, on examination after death. A fissure was also perceived running across the base of the process. A female, with whom he was in bed, had been awakened before the shot was fired, and she stated that, notwithstanding the loudness of the report, the murdered man never stirred a limb, but seemed to continue his sleep undisturbed.

The fatal result in gunshot fractures of the odontoid may be due to displacement of the atlas, as when the fracture occurs from other causes. The following case, reported by Richet,[4] is an example:—

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[1] Medical Jurisprudence, 5th Am. ed., p. 272.

[2] Ed. Med. and Surg. Journ., vol. xlv. p. 9.

[3] Holmes' System of Surgery, vol. ii. p. 395, 2d edit.

[4] Malgaigne, Fractures et Luxations, tome ii. p. 327.

CASE 8.—A man, æt. twenty-two, shot himself in the neck; among other symptoms the articulation between the atlas and axis was noticeably affected; he could turn the head only as he turned his entire body, and was compelled to support the head with his hand. From six to twelve days the head inclined forwards gradually, until finally the chin rested upon the sternum. He was regularly raised up by two assistants to examine the posterior part of the neck. On the seventeenth day they had scarcely raised him to a sitting position when the flexion of the head was suddenly increased, and without a cry or movement he was quite dead. On examination it was found that the ball had fractured the odontoid process at its base; the anterior atlo-axoidean ligament was destroyed, and the articular capsules; the other ligaments were intact.

There may be a partial fracture of the odontoid, or chipping off of its anterior surface, from a gunshot, without immediately dangerous symptoms. The following singular case[1] of gunshot was admitted to Bellevue Hospital:—

CASE 9.—W. M., aged forty years, Swede; seaman; admitted November 8, 1870; attempted to commit suicide by discharging a pistol into his mouth, it being pointed backwards, and a little upwards; was not rendered unconscious, but states that he at once felt severe pain in right side of neck, and noticed loss of power in right arm; a ragged wound is seen on right side of frænum linguæ; has incomplete paralysis of right arm; can raise the elbow only about a foot from the side, and cannot carry the hand to his mouth; power over the flexors is diminished; complains of soreness over right scapula; feels drowsy and dull; on next day had a marked stiffness of neck, rotation being limited. He had an attack of pneumonia, from which he recovered; stiffness of neck and paralysis continued until December 27, when he sat up in bed and drank a cup of coffee; he remained sitting a few minutes, then fell suddenly backward and was dead.

Autopsy.—The ball had passed backwards carrying away a portion of the left side of the anterior ring of the atlas, and lodged on the anterior surface of the summit of the odontoid process, a little to the left of the median line, being flattened over the process so as to stride it; the anterior part of the superior articular surface, involving the base of the process, had been carried away by the ball; there was caries of the bone where injured, and of the left superior articular surface of the atlas; cord softened opposite the injured bones, but no displacement, nor other apparent injury of odontoid or transverse ligaments.

Mr. Alcock,[2] in his *Observations on Complicated Surgical Injuries*, reports a case, "showing the occasional absence of all urgent symptoms in a fracture of the body of the second cervical vertebra," with illustrations. This was a gunshot injury of the body of the second vertebra in which the odontoid process seems to have been as completely deprived of support as when fractured; and is not unlike the cases of fracture of the body of the axis at the base of the process:—

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[1] Notes by Dr. St. John, House Surgeon.

[2] Lond. Med. Gaz., July 30, 1839, p. 584.

CASE 10.—W. B. was struck in the mouth by a musket-ball, May 28, 1836, breaking two incisor teeth, and the patient supposed that he spit it out; on the fifteenth day he was discharged to duty at his own request; admitted again in thirty-eight days, with great difficulty of swallowing; stiffness of back of neck; inability to protrude the tongue; slight obstruction to respiration; pain up the side of his head and neck; sank rapidly, and died on twenty-fifth day after re-admission.

Autopsy.—Ball had destroyed the body of the axis, leaving many fragments in the cavity, exposing the theca vertebralis; no injury to the cord.

III. FRACTURES FROM EXTERNAL VIOLENCE.—External violence may be applied in several directions to the head or neck, and produce fracture of the odontoid process.

(*a.*) *Violence applied to Forehead.*—In the following case the force of the violence was received upon the forehead, and though fracture occurred, the patient suffered so slightly as to resume an active and laborious business, and prosecute it for several months. It will be noticed that the subject of the accident had previously been accustomed to take mercurials and iodide of potassium, and it is possible there was an unusual fragility of his bones. The case occurred in the practice of Dr. Bigelow, of this city, and was reported by Prof. Parker.[1]

CASE 11.—A milkman, forty years of age, of active business habits, addicted to the free use of liquors, suffered from occasional attacks of rheumatism, for which he was accustomed to take mercurials, followed by liberal doses of iodide of potassium. On August 12, 1852, he was thrown violently from his carriage upon his head and face; he arose, and complained only of faintness, rode home two miles; next day had swelling of neck, pain in back part of head, inability to rotate the head; no paralysis. On fifth day an irregularity was detected in the region of the atlas and axis; began to walk around, supporting the head with one hand applied to the occiput, but had pain in this region. The deformity now consisted of a prominence just below the base of the occiput, to the left of the central line of the spine, with a corresponding indentation. On the ninth day he rode out, and then resumed his former duties of distributing milk to his old customers. During the next four months he continued actively at work, but complained much of pain in his head. About January 1, 1853, the pains became more severe, and he heard a snapping in his neck. January 11, after his day's work, he complained of feeling cold, and of numbness of his limbs; on the following day had numbness of his sides; dragged his feet when he walked; died instantly, while sitting in a chair, five months after receipt of injury.

Autopsy.—Odontoid process fractured and inclining backwards towards the cord; blood was found effused between the fractured surfaces; the ligaments of the process were normal, but the occipito-axoid ligament was partially destroyed; spinal cord was healthy.

Hammick (*Pract. Remarks on Amput., Fract.*, &c., p. 183) remarks: " A fracture of the dentatal process is a rare accident; but when it happens, it is usually not from a blow at the back part of the neck, but from one in front, striking the head back." Numerous cases prove the fallacy of this opinion.

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[1] New York Journal of Medicine, vol. x., N. S., p. 164.

(*b.*) *Fracture from Violence applied to the Back Part of the Neck.*—The following is reported by Costes.[1]

CASE 12.—A boy, aged fifteen, was thrown to the ground, and received blows upon the back of the neck; from that moment the movements of the neck were embarrassed, and the head was inclined forwards. Four months later he was suddenly seized with pain in his right arm and leg. Eight days after he lost the entire use of his extremities, and entered hospital. There was a hard swelling on the back of the neck, projecting a little to the right side; several applications of leeches relieved his pain, and he recovered slight power over the arm; the chin inclined to the left side, and was depressed nearly to the thorax. He died four months and a half after the accident.

Autopsy.—The atlas was luxated forward, the right condyle being much in advance of the left. The right articular facet had completely left that of the axis. The left facet still covered the anterior half of that of the axis. The atlas had become displaced forward and downward, at an angle with the spinal column, and its right articular facet corresponded with the right *fossæ* of the anterior surface of the axis; fibrous tissue and cartilage of incrustation was here found, proving that the luxation was of long standing. The odontoid process was fractured off at its base and carried forward with the atlas, and lay in a nearly horizontal position; it was united by bone to the axis. The posterior arch of the atlas had approached the body of the axis so as to leave a transverse fissure two lines on the left and four-fifths of a line on the right.

The following case was reported by B. Phillips,[2] and was regarded at the time as being remarkable for the length of time which the patient survived the accident.

CASE 13.—A man fell from a hay-rick striking upon back of head, "stunned," but on third day resumed work, having a stiffness of neck; the stiffness of neck continued, with inability to rotate the head; at the end of three weeks a small tumour was apparent over the second cervical vertebra; a tumour appeared in the pharynx in the region of the body of the axis; subsequently had pleurisy, and at the end of nine months general dropsy appeared, and he died forty-seven weeks from the injury with hydrothorax; had no symptoms of paralysis of motion or sensation.

Autopsy.—Fracture of atlas behind articular surfaces, and of odontoid process of axis; dislocation of atlas forward upon axis in an oblique direction, downwards and forwards; atlas resting upon same plane as axis, to the body and transverse processes of which it became attached by perfect bony union while the posterior fragment had suffered no displacement; there were two spinal and four transverse foramina.

(*c.*) *Fracture from Violence applied to the Side of the Head.*—Fracture may occur when the injury is received upon the lateral portions of the head. Mr. Spangenbern[3] reported the following case:—

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[1] Malgaigne, Fractures et Luxations, tome ii. p. 329.

[2] Med.-Chir. Transact., vol. xx. p. 78.

[3] All. Rep. Jan. 1864, Ed. Med. and Surg. Journ., vol. lxiv. p. 527.

CASE 14.—A man, aged twenty-eight, fell from a horse upon the side of the head, July 8, 1839; rode half a league when he heard something give way and he fell insensible to the ground. On examination a small swelling was found over the left parietal bone, an enlargement at the upper part of the nape of the neck over the atlas in which was a movable tumour having the form of the spinous process of the seventh cervical vertebra; pressure on this tumour or an attempt at rotation of the head caused acute pain, and a crepitating sound was heard; the head hung forward with the chin on the sternum; no symptoms of injury of spinal cord; recovered so as to be able to walk about, having the head supported in an apparatus; subsequently inflammation occurred, abscesses formed, and he died worn out by hectic, but without any affection of the spinal cord, in October, 1841.

Autopsy.—Posterior arch of atlas was fractured near its articular process; it was carious and absorbed to a considerable extent; body and transverse processes of axis presented the same kind of degeneration; odontoid process was fractured and its ligaments in part destroyed; spinal cord uninjured.

But it is not necessary that the violence should be applied to the head to cause this fracture. It may occur when the injury is received upon the back of the neck. Violence applied over the axis posteriorly is the equivalent of violence applied to the forehead, and is followed by the same results, as appears from the following case occurring in Bellevue Hospital.[1]

(*d.*) *Fracture from Violence applied to Back of Neck.*—

CASE 15.—A man, æt. forty-nine, was admitted to Bellevue Hospital Oct. 12, 1868; he was intemperate; had suffered from primary syphilis; was at this time complaining of pains in the right thigh, knee, and hip. He had also a hard immovable tumour over the upper cervical vertebræ of the size of an English walnut, which he stated was the result of a blow received upon the part a few months previously. Several days after admission he began to complain of pain in the neck and sleeplessness; the pain was aggravated by motion. On the 28th of October, he was found to be partially paralyzed—he could not move his right arm at all, but could stir his fingers, but without sensation. The left hand and arm were less paralyzed. Both legs and feet were similarly affected. There was marked diminution of sensibility over the entire surface below the neck. There were no cerebral symptoms; pupils normal. He stated that the paralysis came on suddenly after sitting up in bed a few moments, and that he had the same symptoms the evening before, after his neck was rubbed with liniment. On the following day the paraplegia was more marked, but no other symptoms present; mind clear; passed water and feces voluntarily; respiration normal. Died suddenly at 11.30 P. M.

Autopsy.—On examination it was found that the first cervical vertebra was dislocated forward, and the odontoid process broken off, and carried with the atlas; there was an old ecchymosis at the seat of fracture; cord and its meninges apparently natural.

The preceding cases illustrate the various predisposing and exciting causes of fracture of the odontoid process. Other features connected with these fractures are as follows:—

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[1] Notes by Dr. W. H. Kaazenbach.

IV. FRACTURES OF THE ODONTOID PROCESS MAY AT FIRST HAVE SLIGHT SYMPTOMS.—Fracture of the odontoid process may occur, and yet produce so little effect that a person, recovering from the shock of the injury, may resume his occupation as a labourer, and continue for a considerable time before the dislocation creates any ill effects. The dislocation may then occur suddenly, and produce immediate death, as in Case 11, or it may proceed gradually, and produce paraplegia and death. The following case, admitted to Bellevue Hospital, illustrates the latter result.

CASE 16.—A labourer was admitted to Bellevue Hospital with the following history: Three months previously he had fallen from a building and received a blow upon the head, which he thought sprained his neck. He continued his work for about six weeks; at first he suffered no inconvenience, but finally a swelling appeared upon the upper part of the back of the neck, which was very painful. He soon after noticed that his left arm was growing weak, with inability to raise it freely; the right arm also began to be impaired in its motions; the lower extremities were not affected at this time. During the following three weeks the deformity of the neck increased rapidly, the head became fixed with the chin carried to the left side and upward, and the occiput to the right side and downward. The paralysis of the left arm became complete as regards its movements, and that of the right was much impaired; the patient also lost all power over the left leg; sensation, though not lost, was impaired in the upper and lower extremities. He had nearly constant headache; his face expressed great distress; the left arm became œdematous, purple, and cold; the face also became purple, and the skin generally showed by its dusky hue imperfect aeration of the blood. He had severe attacks of dyspnœa, followed by thoracic respiration; involuntary action of bowels and bladder; great emaciation. His position in bed was peculiar, being recumbent, with the head fixed, the chin thrown upwards and to the left side; eyes protruding; facial expression that of great suffering. He seemed at times to recover slightly the sensibility of his extremities, and a very slight power of motion. His mind remained undisturbed; he died 160 days after the injury.

Autopsy.—Body emaciated; hands and feet œdematous; brain and membranes normal; the odontoid process was fractured and carried forward so as to lie in a nearly horizontal position in contact with the anterior ring of the atlas; the atlas was dislocated forwards and slightly to the left side; the articular facets resting anterior to the body of the axis; the spinal canal was diminished to three-eighths of an inch; there was no rupture of ligaments, or other fracture.

Palleta[1] reports the following case:—

CASE 17.—A robust porter, in the prime of life, fell under a weight which he was unable to sustain upon his shoulders. He arose, and passed a month without consulting any one, but finally was taken to the hospital. The head was inclined forward, but especially to the left; at the upper part of the neck was a considerable depression; no symptoms of paralysis; the head could be easily raised to its natural position, but when unsupported fell upon the left shoulder. On the sixth day after admission, the patient was seized with violent convulsions and suddenly died. It was found that the odontoid process was fractured at its base. Ligaments sound, and no displacement mentioned.

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[1] Malgaigne, Fractures et Luxations, tome ii. p. 327.

V. MULTIPLE FRACTURES.—Fractures of the odontoid process are frequently associated with fractures of the atlas or axis, or of both vertebræ. These cases are rarely immediately fatal. The following is an example of fracture of the process with fracture of the atlas:—

CASE 18.—A man fell down stairs; had loss of motion of the limbs except the left lower extremity; sensibility of right side morbidly acute; that of the left destroyed except on the abdomen; second day had pain in right arm; skin of left side less sensible; third day morbid sensibility of right side less, and sensation of left returning; thinks his arms lie across his chest; fifth day had slight motion of left arm, and power of moving right leg increased; death on fifth day.

Autopsy.—Atlas broken in two places; line of fracture diagonal, and through left vertebral foramen; pivot of axis broken off and a small piece of body also; fifth vertebra fractured through the body; no pressure on the cord at site of either fracture; cord broken down and disorganized opposite fifth vertebra.[1]

Although fracture of the odontoid process has been generally regarded as necessarily fatal, yet recovery is possible in at least two ways. Neither of those methods, however, has been proved to be by union of the fractured bone. It is doubtless true that this isolated bone, fractured at its base, may unite; for in several of the pathological specimens such union seems to have taken place. But irreparable damage had already been done, and the union was not of a kind to save the patient from the fatal results.

VI. FRACTURE OF THE ODONTOID PROCESS FOLLOWED BY THE ESCAPE OF THE PROCESS, AND RECOVERY.—The following well-authenticated case of fracture of the odontoid process, with recovery, after the escape of the process, was reported by Dr. Bayard.[2]

CASE 19.—Girl aged six years, fell five feet, striking on head and neck; was unable to move her head without pain, and carefully supported her chin with her hand when she walked; head inclined forward and to the right side, and any attempt to rotate it caused great pain; no swelling or irregularity of neck. Two months after had convulsive movements of arms and legs, and inability to support her head, followed by paralysis of body below the neck; continued in this condition for three months, after which she gradually recovered power of walking. Nine months after accident could walk well, but supported her chin in her hand; head rested upon right shoulder, and could not be raised without severe pain; an irregularity of neck gave appearance of luxation of axis and atlas; wore an apparatus which raised the head, and she recovered power of rotation; a depression was seen behind right sterno-mastoid, and a corresponding elevation on the opposite side. About two years and a half after the accident, a post-pharyngeal abscess formed from which a bone escaped which was decided to be the odontoid process, abscess closed, and patient recovered.

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[1] South's Chelius, vol. i. p. 585.

[2] Canada Med. Journ., Dec. 1869.

Mr. Hilton[1] quotes the following case from Guy's Museum book, with an illustration, which represents a portion of the odontoid process removed.

Case 20.—Mrs. G., a patient of Mr. Babbington, in 1834, a married woman, who had worked hard at washing, and been much exposed to cold. Five years before she had an attack of pleurisy, but was not aware of having taken mercury, at least not to salivation, and she never had syphilis. Four months previously to her seeking advice, she began to find her neck stiff, with a pain at the back of her head. These symptoms increased until one day, on coughing, she brought from her mouth a piece of bone, and subsequently some smaller fragments—and a portion of the atlas or first vertebra seen in the specimen. She was visited for some months afterwards, when the head was nearly fixed, and there was a discharging ulcer at the back of the pharynx. The patient was last seen in October, 1838, when she was in tolerable health, and serving at the bar of a public house.

VII. Fracture of the Odontoid Process and Recovery, with the Formation of a False Joint.—Mr. Curling[2] reports the following case of fracture of the odontoid process, and the *formation* of a false joint.

Case 21.—A robust man, aged forty-two, walked into the hospital, May 17, 1838, having just fallen a few feet from a ladder upon the back part of his head and neck. There was no mark of external injury, but he complained of slight pain in the head, and stated that, since the accident, he had been deaf; he appeared stupid, answering questions reluctantly; pulse slow; pupils acted freely. Second day he appeared somewhat better, but complained of pain in the back of the neck; became delirious during following night. On the third day was unconscious; pupils contracted. On the fourth day became sensible; then insensible, with stertorous breathing. On being bled he became again sensible, but soon after suddenly expired.

Autopsy.—Brain congested; more fluid than usual in the cavity of the arachnoid and lateral ventricles. The foramen magnum was smaller than usual, and the odontoid process was discovered to be movable. On dissection the process was found to be connected as usual to the occipital bone by the perpendicular and moderator ligaments, but was attached to the second vertebra by means of two slender ligaments, which passed from it to their insertion near the superior articulating processes of the latter. The transverse ligaments, larger than usual, flattened horizontally and polished above and below, formed a distinct inter-articular ligament between the odontoid process and the body of the second vertebra. There was a communication between the two articulations in front, where there was also a slight spinous projection of the processus dentatus. Behind this projection the surface of bone which rested on the transverse ligament was flattened, and tipped with thin cartilage. The corresponding part of the second vertebra likewise presented a distinct articular surface. At this spot the theca vertebralis was much thickened, closely adherent, and contained a small cyst filled with an inspissated fluid, like that found generally in ganglions. The superior articulating processes of the second vertebra, and the corresponding surfaces of the first, were remarkably large. There was no appearance of injury or disease about the spinal cord or the ligaments of the vertebra.

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[1] Lecture on Rest and Pain, p. 104, London, 1863.

[2] London Hospital Reports, vol. i. p. 142.

Mr. Curling concluded that this state of things had existed for a long period, as there was no evidence of recent injury; the false joint was covered with cartilage; a bursa had been developed; a large surface had been formed upon the second vertebra for the play of the process. He regarded these appearances as the result either of an original malformation, or of accidental violence before the third year. Death was not due to this condition of the process.

An analogous case was presented to the London Pathological Society, December 1, 1857, by Mr. Shaw.[1] It was found in a dissecting-room subject, and was therefore without a history.

CASE 22.—The specimen consisted of the occipital portion of a skull, with the atlas adhering to it by anchylosis, and the axis, having its odontoid process detached, as a distinct bone. The odontoid process was of its normal size and figure; it was separated at its base, on the under surface of which, as well as on the upper surface of the body of the axis, were the appearances of an articulation by a false joint having existed during life.

Mr. Shaw was of the opinion that the separation of the process was not the result of violence, but that it had been caused by disease occurring in early life, when the process was still an epiphysis. That view was supported by the evidences of disease having existed at one time in the joints of the occiput and atlas. These two bones were anchylosed, and the union was so intimate that it amounted to complete fusion of the articular surfaces; there was also slight distortion, the atlas, in the process of union, having been projected somewhat forwards, and turned round at the same time on its centre, so that the right side was more advanced than the left; in this way a perceptible encroachment on the canal for containing the spinal marrow had been produced. The morbid appearances denoted that the disease thus affecting parts in close proximity to the odontoid process had prevailed at a distant period, probably when the individual was young It is not till about the fourth year that that process ceases to be an epiphysis, and is joined to the body of the axis by bony union. Accordingly it is reasonable to conclude, that if the disease had been active at that period, the process of ossific union would have been interrupted; and we can readily understand that afterwards the junction would take place by the formation of a false joint.

However these two cases of false joint are to be explained, the following remarkable example, also discovered accidentally in a dissecting-room subject, would seem to admit of explanation only on the supposition of a previous fracture. It was reported by Dr. A. Friedlowsky :—[1]

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[1] Transactions Lond. Path. Soc., vol. xv.

CASE 23.—*Apparent Fracture of the Odontoid Process.*—Subject, an adult; atlas was normal in its articulations with the condyles of the occiput above, and with the axis below; the anterior tubercle was enlarged; upon the posterior surface of the anterior arch the articular surface of the odontoid process was well marked, but instead of being round or oval, as usual, it was triangular, with a rounded base above, and a point below, and irregular sides. On examining the anterior half of the atlas from below, a new articulating surface was discovered; it extended from the anterior border of the arch of the atlas, obliquely backwards and upwards, and was deepened in the middle into an oblique oval-shaped channel. The prominence of the anterior margin of this articulating fossa, which had several projecting bony processes, gave the peculiar enlargement of the anterior tubercle. The diameter of this new-formed articulation was upwards of six lines broad, and four lines antero-posteriorly. The lateral processes, the foramina, and the posterior arch of the atlas were normal. The axis was entirely normal except its odontoid process. This was short, and had apparently dwindled down to a roundish knob. Its upper portion, which normally has a smooth surface anteriorly and posteriorly for the arch of the atlas and transverse ligament, presented only a blunt point, smoothed in front and behind more than at the sides, and had a waxy lustre noticeable in the new-formed articulation. On placing the atlas and axis in proper relations with each other, it was found that the knob-like extremity of the odontoid process fitted into the new-formed articulation on the under surface of the anterior arch of the atlas; and in the movements of the head from right to left, the atlas moved upon the extremity of the process which passed along the oblique groove mentioned.

Dr. F. regarded these conditions as acquired, and the result of fracture of the odontoid process from external violence, because the articular surface of the odontoid process was found well marked on the posterior surface of the arch of the atlas, and there were no evidences of necrosis. The upper portion of the process was not found, but that did not invalidate his conclusion. The anomalous displacement of the odontoid process forwards and downwards he attributed to certain deep muscles of the neck, especially the innermost fibres of the longus colli.

As regards the date of the fracture, he fixed it at an early period; as the process is developed from two points of ossification, which gradually form a union with each other, and with the corresponding point of ossification of the axis, the neck, head, and point of the process remain for some time cartilaginous; such condition would favour a fracture at this period.

On reviewing the preceding cases the following general conclusions are deducible:—

Mode of Death.—The mode of death varies very much in fractures of the odontoid process:—

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[1] Medizinischer Jahrbucher, xv. Band, p. 233.

1. It may be instantaneous from pressure of the broken process upon the medulla oblongata. In these cases the victim is literally pithed.

2. Pressure of the process may be gradual. In such cases the pressure may be upon the anterior columns of the cord, when paralysis of motion of the extremities is first experienced—generally in one hand first, then in the foot of the corresponding side, and finally complete paraplegia of all the parts below the middle of the neck occurs, and death follows from exhaustion.

3. Displacement of the atlas upon the axis may suddenly occur, and death follow from compression of the cord.

4. Displacement of the atlas may be very gradual. In these cases, and they are quite numerous, the patients have maintained the head in its position for a considerable period without any marked symptoms; whenever they have continued to move about, grave symptoms have finally supervened from a gradual luxation of the atlas upon the axis. It is surprising to what an extent the spinal canal may be encroached upon, and the functions of the cord may be more or less preserved. In one case, it was three-eighths, and in a second one-fourth of an inch in diameter.

Symptoms.—If the function of the odontoid process is to poise the head upon the spinal column, we should naturally anticipate that the most important and constant symptoms of fracture would be those which show that this support is lost. And such is the case. Patients carry the head as if steadying a weight upon it, unsupported. In all their movements, the centre of gravity of the head is carefully maintained in its proper relations to the apex of the spinal column. The foramen magnum being a little posterior to the centre of the base of the skull, patients generally elevate the chin, in order to preserve the centre of gravity. Whenever they wish to elevate the eyes above the ordinary level, they support the occiput in the hand, and in looking downward they support the chin in the hand. If the relations of the head to the spine are disturbed by a shock, they seize the head upon the sides with both hands, and hold it firmly for a time. On attempting to rise from bed they elevate the head with the hand applied to the occiput, and in bed move the head cautiously with the hands.

Other symptoms are especially related to the complications which may exist.

External appearances are not characteristic, and are indicative of changes in the position of the atlas or axis.

Whenever the fracture occurs from chronic diseases of the articulations, as in Cases 4 and 6, we have superadded, difficulty of swallowing, excessive pain of head and neck due to pressure upon the first cervical nerves, inability to rotate the head, and finally, all the symptoms of separation of the process or the odontoid ligaments.

Prof. Rust, who recorded thirteen cases of disease of the articulation of atlas and axis, has given a very perfect description of the symptoms which are present when the odontoid process yields or its ligaments are destroyed. There can be no doubt that in his cases this fracture actually existed, or the odontoid ligaments had separated, for they are the counterpart of the cases alluded to.

> "After a certain length of time, the pain becomes more violent when the head is inclined to one side; * * * difficulty of swallowing and respiration continues to increase, and the pain, which is concentrated about the occiput, becomes almost insupportable on the least motion of the head. The head now falls on one shoulder, and usually on the right one, because the disease most frequently affects the left side of the vertebræ. * * * The pain in swallowing, speaking, and breathing recurs; the head becomes inclined a little backward, or to the side opposite its former position. The patient cannot obtain ease in any position; and he can neither rise nor lie down without supporting his head with both hands."[1]

A portrait of a person suffering from this disease is given by Prof. Rust, which strikingly resembles the appearance of the patient with fracture of the odontoid process (Case 16) who came under my own care.

The reviewer says:—

> "We hardly ever witnessed so distressing a representation of the human visage; the fixed teeth, curled lips, obliquity of the eyes, contracted brow, rugous forehead, erect hair, and the sharp lines formed by the muscles in consequence of the state of emaciation."

Prognosis.—Although most of the cases reported were fatal, a review of these records shows that the prognosis in fractures of the odontoid, if not attended with immediate displacement of the atlas, is very favourable. Cases which have been recognized and properly treated, have recovered. In other instances, not recognized, the patients have lived for considerable periods, the fatal changes taking place very gradually. These changes were such as could at any time have been arrested by proper appliances.

Still other cases of recovery are recorded in which the process separated and was discharged. Anchylosis of the axis and atlas generally follows recovery.

Treatment.—The treatment, as in all fractures, must be absolute rest to the fractured bone. This can best be secured by an apparatus, which not only fixes the head in its central position, but which supports the upper cervical vertebræ firmly in their proper relations to the head, and to each other. Mr. Hilton[2] beautifully illustrates this latter point in a case of supposed fracture of the odontoid process in which, when support was removed from upper part of the back of the neck, a sense of suffocation followed, threatening immediate death. The patient may be placed in a recumbent position, with sand-bags by the side of the head, and a fold of cloth under the neck, or a splint may be applied to the back and head, as was practised by Dr. Bayard, with success. The latter is preferable, as it allows the patient to move about.

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[1] Review of his work on Arthocacology, London Med. and Phys. Journ., vol. xli. p. 342.

[2] Lectures on Rest and Pain, op. cit.